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Surgical site infection after thyroidectomy: a rare but significant complication

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Abstract

Background—Surgical site infections (SSIs) after thyroidectomy are rare but can have significant consequences. Thyroidectomy is a clean case, and the patterns for use of prophylactic antibiotics vary. We hypothesized that patient and operative characteristics may predict a higher risk of SSI, and that SSI are associated with other complications leading to increased resource utilization.

Methods—Data from the American College of Surgeons National Surgical Quality Improvement Program dataset for patients who underwent thyroidectomy through cervical incisions from 2005–2011 were included. Bivariate analysis using *t*-tests and chi-square tests were performed, and variables with $P < 0.2$ were considered for inclusion in a multivariate logistic regression model.

Results—A total of 49,326 patients underwent thyroidectomy from 2005–2011 and 179 (0.36%) had an SSI. On multivariate analysis, the strongest predictors of SSI were operative time ($P < 0.001$) and wound classification clean-contaminated (odds ratio 6.1; 95% confidence interval, 3.6, 10.3). Preoperative factors associated with SSI on multivariate analysis had lower magnitudes of influence on SSI risk but included obesity, alcohol use, and nonindependent functional status. Patients with SSI were more likely to have a wound dehiscence, renal insufficiency, bleeding requiring transfusion, and return to the operating room on a multivariate model of outcomes.

Conclusions—Although rare, SSI after thyroidectomy are associated with other postoperative complications. We have identified preoperative and intraoperative factors that are associated with SSI, and this may help identify high-risk patients who may benefit from selective use of antibiotics.

Keywords

Surgical site infection; Thyroidectomy; Prophylactic antibiotics

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The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS-NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Disclosure
The authors reported no proprietary or commercial interest in any product mentioned or concept discussed in this article.

1. Introduction

Routine antibiotic prophylaxis is not recommended for clean surgical cases [1], and thyroidectomy is almost always classified as a clean case. Practice patterns vary widely among endocrine surgeons with a recent survey revealing that 62% of surgeons who responded "almost never" use prophylactic antibiotics and 26% "almost always" administer antibiotics before incision [2]. Utilization varied by country and type of hospital but did not seem to be influenced by surgeon caseload or previous experience with infected wounds after cervical endocrine cases.

The reduction of surgical site infections (SSIs) is a goal of multiple groups and stakeholders. In 2002, the Centers for Medicare and Medicaid Services and the Centers for Disease Control and Prevention introduced the Surgical Infection Prevention Project, and in 2004, a partnership of private organizations implemented the Surgical Care Improvement Project [3,4]. Surgical Care Improvement Project measures have been adopted at every surgical center and hospital in the United States, and every person who works in the surgical arena is familiar with the language and protocols designed to improve the quality of surgical care and reduce complications, including SSI.

Rates of SSI in thyroidectomy are quite low, reported to be between 0.5% and 3% in most series [5–9], but the consequences can be costly and morbid for patients. Surgical patients as a whole who develop SSI have longer hospital stays, higher readmission rates, and higher hospital costs than patients who do not [10,11]. An unsightly wound infection in the neck is particularly conspicuous and cannot be hidden under clothing like an abdominal wound infection after a colon surgery or trauma. Given the proximity to critical structures, a neck infection often cannot be treated with simple incision and drainage with open packing. Although SSI in contaminated abdominal wounds affect far more patients than SSI after clean thyroid surgery, the emotional toll and quality of life issues may be much greater. There are some studies that suggest that specific factors about an operation or certain patient characteristics may increase the risk of wound infection. Bergenfelz, *et al.* [7] reported higher rates of wound infection when central lymph node dissection is done with a thyroidectomy compared with thyroidectomy alone; Dionigi, *et al.* [8] found that a lobectomy had lower rates than total thyroidectomy. Buerba, *et al.* [12] reported higher rates of wound complications after cervical endocrine operations in obese patients. One randomized trial has been done in thyroidectomy [13], but it excluded patients with obesity, diabetes, and other high-risk variables. In breast surgery, there are studies suggesting that patient factors such as obesity, smoking, American Society of Anesthesiology (ASA) class, and diabetes are associated with increased risks of SSI [14,15]. Because the rate of infection is much lower in thyroid patients, risk factors traditionally associated with infection in other procedures may not be applicable in this population. As surgeons become more specialized in their practices, it is important that they understand how to best apply evidence to their particular patient population. For a thyroid surgeon with a higher than expected rate of infection, it is important to identify what factors might be modifiable to help them improve their outcomes.

Development of any infection is multifactorial, and all thyroidectomy patients are not alike. The goals of our study, then, were to (1) determine the incidence of SSI after thyroidectomy from a large national database, (2) define preoperative and intraoperative variables that predict higher risk of SSI, and (3) determine if SSI in thyroidectomy is associated with other postoperative complications leading to increased use of health care resources. Ultimately, we hope to help identify patient and operative characteristics that can help guide a thyroid surgeon's use of selective perioperative antibiotic prophylaxis instead of using prophylactic antibiotics "always" or "never", perhaps using them in patients at the highest risk of SSI is a better use of health care resources.

2. Materials and methods

The National Surgical Quality Improvement Program (NSQIP) Participant User Files for 2005–2011 were used for this retrospective analysis, which included all patients with a Current Procedural Terminology code for all types of cervical thyroidectomy: partial or total lobectomy (60,210; 60,212; 60,220; and 60,225), total thyroidectomy (60,240), total thyroidectomy for malignancy with limited neck dissection (60,252) or with radical neck dissection (60,254), redo thyroidectomy (60,260), and cervical approach thyroidectomy for substernal gland (60,271).

The primary outcome measures for our analysis was 30-d postoperative SSI, which includes the following three categories recorded in NSQIP: superficial incisional SSI, deep incisional SSI, and organ space SSI. Secondary outcome measures included postoperative length of stay, need for reoperation within 30 d of the index procedure, and the remaining 17 specific complications tracked by NSQIP other than SSI (wound dehiscence, pneumonia, unplanned intubation, ventilator dependence for >48 h, pulmonary embolism, progressive renal insufficiency, acute renal failure, stroke, coma >24 h, peripheral nerve injury, cardiac arrest requiring cardiopulmonary resuscitation, urinary tract infection, myocardial infarction (MI), bleeding requiring transfusion of packed red blood cells, deep venous thrombosis, sepsis, and septic shock).

Preoperative characteristics, intraoperative characteristics, and postoperative outcomes were compared for patients who did not experience SSI with those patients who did experience SSI in the 30 d after thyroidectomy using Pearson chi-square tests for categorical variables and Student *t*-test for continuous variables. Multiple logistic regression analysis was used to determine the independent effects of these variables on SSI after adjusting for patient and procedure-related variables. The following variables were considered for inclusion into the logistic regression models: age, gender, specific type of operation, body mass index (BMI), diabetes mellitus, ASA classification, tobacco use within past year, more than two drinks of ethanol per day within 2 wk period in the past year, ascites, steroid use for chronic medical condition within 30 d of surgery, chemotherapy in 30 d before operation, radiotherapy for malignancy in the past 90 d before operation, >10% weight loss in 6 mo before operation, history of chronic obstructive pulmonary disease (COPD), history of revascularization or amputation for peripheral vascular disease, hypertension requiring medication, previous cardiac surgery or percutaneous coronary intervention, history of congestive heart failure (CHF), history of MI in 6 mo before surgery, currently on dialysis, presence of disseminated cancer, functional status, current pneumonia, operative time, and wound classification. The continuous variable of BMI was collapsed into categories as appropriate. Any variable with $P < 0.2$ on bivariate analysis was used as the criterion for entry of a predictor variable into the logistic regression model. Analysis of specific postoperative complications and SSI were performed using Pearson chi-square tests, and the same $P < 0.2$ criteria was used for inclusion into multivariate logistic regression models. All statistical analyses were performed using Stata version 11.0 (Stata Corporation, College Station, TX). Based on University of Wisconsin-Madison policies and the federal Common Rule, 45 CFR Part 46, data used in this study do not meet the definition of research involving human subjects and therefore does not require Institutional Review Board review.

3. Results

3.1. Bivariate analysis of variables associated with SSI

A total of 49,326 patients underwent thyroidectomy from 2005–2011 and 179 (0.36%) had an SSI. The vast majority of SSI was in the form of superficial wound infection (73%) followed by deep incisional SSI (18%) and organ space SSI (9%). Table 1 provides a summary of the bivariate analysis of patients with and without SSI. There was no difference in age or gender of the patient groups. The specific type of operation was not statistically associated with SSI, but patients who underwent thyroidectomy with central lymph node dissection and thyroidectomy with radical lymph node dissections had slightly higher rates of SSI than those who had thyroidectomy alone. Reoperative thyroidectomy was not associated with SSI. BMI was different between the groups with patients who had SSI having a higher mean BMI. Breaking down the continuous variable into categories is more revealing than looking at the mean: BMI <19 (underweight) had higher rates of SSI as well as BMI >30 (obese). Presence of diabetes, whether controlled with insulin or not, was associated with SSI. Higher ASA class, which takes into account multiple comorbidities of individual patients, was associated with SSI. Smoking rates were higher in the group with SSI, although did not reach the statistical significance. Alcohol use was higher in the group with SSI, but presence of ascites was very low in both groups. Steroid use for a chronic condition was almost three times higher in the group with SSI, as was significant weight loss. The presence of disseminated cancer was higher in the group with SSI, but chemotherapy rates and radiation therapy rates did not differ significantly. Rates of peripheral vascular disease, hypertension, MI, or interventions for coronary disease were not different, but history of severe COPD and CHF were higher in the SSI group. Rates of dialysis were no different. Although rare, a preoperative diagnosis of pneumonia was associated with SSI, and patients with decreased functional status had higher rates of SSI.

Intraoperative characteristics examined included operative time, which was 40 min longer in the group with SSI, and the surgeon assigned wound classification (Table 2). In patients without SSI, 98% of the wounds were classified as clean, but only 86.6% of wounds were classified as clean in the group with SSI. Patients with SSI had wounds that were classified as clean-contaminated at a rate of nearly seven times higher than those without, and contaminated wounds were four times higher in the group with SSI. In general, the operative complications collected in Surgeons National Surgical Quality Improvement Program (ACS-

NSQIP) are rare in thyroid surgery, and SSI was associated with higher rates of some of these other complications. Table 3 includes a list of all the postoperative outcomes collected in the NSQIP database in order from the most common to the least. Complications that were associated with SSI included unplanned reintubation, prolonged ventilator use, pneumonia, sepsis, bleeding requiring transfusion, wound disruption or dehiscence, pulmonary embolism, progressive renal insufficiency, and acute renal failure. The absolute numbers of patients experiencing any of these last three complications is extremely low but were more common in the group with SSI. Complications that were not associated with SSI included urinary tract infection, deep venous thrombosis or thrombophlebitis, peripheral nerve injury, cardiac arrest requiring cardiopulmonary resuscitation, MI, septic shock, stroke or cerebrovascular accident with neurologic deficit, and coma >24 h. Patients with SSI had significantly more occurrences of return to the operating room and a significantly longer length of stay that those without.

3.2. Multiple logistic regression models of predictive variables for SSI

A logistic regression model was created that included all of the preoperative variables with a $P < 0.2$ to determine which variables can be used to predict patients with a higher risk of SSI before the operation. ASA class was omitted because many of the individual comorbidities that go into determining a patient's ASA class are included in the ACS-NSQIP, and we are interested in determining which individual factors are most associated with SSI. BMI categories were collapsed into the following three categories for the model: underweight BMI <19, obese BMI >30.01, and a reference range of normal and overweight patients with BMI 19.01–30. From this model (Table 4), obesity was an independent predictor of SSI (odds ratio [OR] 1.8, 95% confidence interval [CI], 1.3–2.5), as were alcohol use (OR 2.7, 95% CI, 1.0–7.4), and nonindependent functional status (partially dependent OR 2.9, 95% CI, 1.0–8.2, totally dependent OR 5.8, 95% CI, 1.3–26.5). Variables that showed a trend and may be clinically associated with SSI included weight loss of >10% in 6 mo before surgery (OR 2.8; 95% CI, 1.0–7.8), use of steroids (OR 2.1, 95% CI, 1.0–4.6), thyroidectomy with central neck dissection (*versus* thyroidectomy, OR 1.5, 95% CI, 0.9–2.5), diabetes (insulin-dependent agents OR 1.7, 95% CI, 0.9–3.3 and oral agents OR 1.7, 95% CI, 0.9–3.0), and history of COPD (OR 1.7, 95% CI, 0.8–3.7). Variables that were not predictors of SSI included the other types of operations included (partial thyroidectomy, thyroidectomy with radical neck dissection, reoperative thyroidectomy, or substernal goiter), underweight patients, diabetes without medications, and history of CHF.

The two intraoperative variables of operative time and wound classification were then added to the model. The risk of SSI attributable to intraoperative variables was much higher than any preoperative predictive value. A likelihood ratio test of the two models was performed and found that the second model that contained the two intraoperative variables is a better fit, and this likelihood ratio test is highly significant ($P < 0.001$). The only preoperative characteristic that remained significant once the intraoperative factors were added was obesity (OR 1.8, 95% CI, 1.3–2.5). The intraoperative characteristics of wound classification of clean-contaminated instead of clean predicted SSI to a much greater degree than any preoperative variable (OR 6.1, 95% CI, 3.6–10.3), and longer operative time remained highly associated with SSI ($P < 0.001$). All other preoperative factors were no longer significant in this logistic regression model (Table 5).

Finally, a logistic regression model was created that included all of the postoperative complications with $P < 0.2$ to see if SSI was an independent predictor of any of the other complications (Table 6). SSI was independently associated with higher rates of wound dehiscence (OR 24.1, 95% CI, 8.1–71.3), renal insufficiency (OR 70.4, 95% CI, 6.6–747.9), and acute renal failure (OR 35.7, 95% CI, 3.4–376.3), which were both extremely rare and probably of little clinical significance, sepsis (OR 75.3, 95% CI, 35.1–161.5), and return to the operating room (OR 5.5, 95% CI, 3.5–8.9) but was not associated with pneumonia, reintubation, failure to wean ventilator, pulmonary embolus, urinary tract infection, bleeding, or length of stay.

4. Discussion

This study finds that the cumulative incidence of SSI within 30 d after thyroidectomy from the ACS-NSQIP is quite low at 0.36%. The vast majority of cervical thyroidectomies (98% in this study) are classified as clean cases, therefore use of routine antibiotic prophylaxis is not indicated according to guidelines. We have defined several predictive variables that may help identify patients at higher risk for SSI who could be considered for selective use of prophylactic antibiotics.

The difficulty in studying this problem is that the incidence of SSI after thyroidectomy is very small, ranging from 0.5%– 3% [5–9]. We know from previous studies about SSI in general that infections lead to higher resource utilization [16]. The studies that have been done to date in thyroidectomy are very likely not to show a difference in SSI rates with use of prophylactic antibiotics because the antibiotics are either administered or not administered to all patients in the studies, and most thyroidectomy patients are at very low risk of SSI. The benefit of prophylactic antibiotics may be small and insignificant when applied across the board, but it is possible that prophylactic antibiotics used in a selective fashion for patients at highest risk of SSI may show a benefit. This has been shown in breast cancer patients [17] and in laparoscopic cholecystectomy patients [18] but has yet to be demonstrated in thyroidectomy. We have identified risk factors that could be used in future studies examining the use of selective antibiotics in high-risk thyroidectomy patients.

Through this analysis of NSQIP data for thyroidectomy, we have found that preoperative factors associated with SSI are much less significant than the wound classification of clean-contaminated and operative time. More than 98% of thyroidectomies in NSQIP were classified as clean, and it is a limitation of this dataset that one cannot discern why these cases were classified the way they were. One can only speculate about factors that could cause a surgeon to change this classification. In rare cases, the trachea may be injured and the respiratory tract entered during the operation, and this would change the wound classification from clean to clean-contaminated. The trachea can usually be primarily repaired if the injury is recognized at the time [19]. Additionally, it can be difficult to estimate which patients will need a lengthy operation before the incision, and longer operative times are associated with SSI. Because they are difficult to predict, these intraoperative factors are not very useful in identifying the high-risk patients preoperatively for selective use of preoperative antibiotics. However, these may be patients who could be treated intraoperatively or postoperatively with antibiotics to reduce the rates of SSI. Although preoperative dosing is recommended for clean-contaminated cases, it is unknown whether delayed dosing of antibiotics at the time of a tracheal injury or during a prolonged operation is beneficial or not and should be the focus of future investigations.

The large numbers and detailed information about comorbidities provided by ACS-NSQIP database allow us to identify modifiable risk factors that contribute to SSI in thyroidectomy. The use of NSQIP data for this type of research has advantages over traditional retrospective studies, primarily because of the large sample size. This database captures many clinically relevant variables using data from both community and academic centers that have been independently audited and validated. We found that, of the preoperative variables associated with SSI, obesity is the most significant risk factor. This has been shown countless times in all types of operations, including thyroid surgery [12]. It can be challenging to get adequate exposure during thyroidectomy in obese patients, and this may contribute to longer operative times in these patients, further increasing the risk of SSI. Operations that include neck dissections often take longer to perform, but there was not a consistent association between type of operation and SSI. Smoking has been seen as a risk factor for wound infection in breast cancer patients using NSQIP data [14], but we did not find a clear association with SSI in thyroidectomy. There was a weak association with history of COPD, although. It is possible that neck incisions are particularly vulnerable to injury in the postoperative period from coughing, but most patients with COPD have a history of tobacco use. Diabetes has been implicated in wound infection rates [15], and there was a weak association with SSI in thyroidectomy.

This study has limitations inherent to all retrospective reviews, and these should be kept in mind when interpreting these findings. Most importantly, we are only able to evaluate and adjust for variables documented in the database, and the ACS-NSQIP does not capture some of the more common complications of thyroid surgery, such as hypocalcemia and laryngeal nerve injury [20]. The most important variable for this study that it does not capture is use of prophylactic antibiotics, so we have no idea which of these patients received antibiotics and which did not. There has been much published data about the use of drains in thyroid surgery and whether drains are associated with SSI [21], but use of surgical drains is not recorded. Return to the operating room within 30 d is a variable captured in NSQIP, but the reason for the return is not captured. In thyroid surgery, this could be for washout of an infection, but it could also be for elective return for completion thyroidectomy or for bleeding [22]. Although there is no clinical reason to believe that more patients with SSI required completion thyroidectomy, there was an association between SSI and bleeding, so some of high rates of reoperations in the SSI groups could have been because of bleeding. Additionally, although the ACS-NSQIP Participant Use Data File is validated, it is an administrative database with potential for coding errors that could affect our analysis and interpretation.

Our analysis suggests that patients who are obese, patients who are heavy users of alcohol, or those who are nonindependent functional status should be considered higher risk for SSI.

These are the patients who may benefit most from selective use of antibiotic prophylaxis if that can be shown in future studies to reduce SSI rates in thyroidectomy. Unfortunately, the greatest predictors for SSI are intraoperative factors that are difficult to predict preoperatively, and discussions on reducing the risk of SSI in this cohort may need to shift toward determining the role for intraoperative or postoperative antibiotics as risks factors become apparent during an operation.

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Table 1

Preoperative patient characteristics and SSI.

Variable	Patients without SSI (*n* = 49,147)	Patients with SSI (*n* = 179)	*P* value
Age, y, mean ± SD	36.4 ± 14.7	35.6 ± 14.8	0.5
Male, %	19.4	24.2	0.11
Operation, %			0.18
Partial thyroidectomy	38	35.8	
Total thyroidectomy	45.3	43.2	
Thyroidectomy with central lymph node dissection	8.7	12.9	
Thyroidectomy with radical lymph node dissection	1.3	2.8	
Redo thyroidectomy	3.7	3.9	
Thyroidectomy with substernal goiter	2.9	1.7	
BMI, mean ± SD	29.4 ± 7.7	30.9 ± 7.8	0.009
BMI category, %			0.004
<19	2.4	3.4	
19.01–25	27	18.4	
25.01–30	30.5	26.3	
30.01–35	20.7	21.8	
35.01–40	10.8	19	
40.01–50	7.1	8.9	
>50	1.5	2.2	
Diabetes, %			0.004
No	88.9	80.5	
Diet controlled	3.4	5.6	
Oral agents	4.2	7.3	
Insulin dependent	3.4	5.6	
ASA class, %			<0.001
I	8.9	5	
II	66.3	55.9	
III	23.7	35.8	
IV	1.1	3.4	
V	0.02	0	
Smoked within 1 y before surgery, %	15.3	19	0.176
ETOH > 2 drinks/d in 2 wk preop	1.1	2.6	0.07
Ascites, %	0.02	0	0.86
Steroid use for chronic condition, %	1.7	4.5	0.004
Chemotherapy for malignancy in 30 d before surgery, %	0.23	0	0.55
Radiotherapy for malignancy in 90 d before surgery, %	0.17	0.65	0.15
>10% body weight loss in the last 6 mo, %	0.8	2.2	0.03
Disseminated cancer, %	0.7	2.2	0.01
History of severe COPD, %	1.9	5	0.002
History of revascularization or amputation for PVD, %	0.32	0	0.48

Variable	Patients without SSI (n = 49,147)	Patients with SSI (n = 179)	P value
Hypertension requiring medication, %	37.5	41.9	0.22
History of MI in 6 mo before surgery, %	0.13	0	0.65
History of percutaneous coronary intervention, %	2	3.3	0.26
History of cardiac surgery, %	1.7	2	0.81
CHF in 30 d before surgery, %	0.2	1.1	0.007
Currently on dialysis	0.4	0.6	0.7
Current diagnosis of pneumonia	0.06	0.7	0.004
Functional health status before surgery, %			<0.001
Independent	99.3	96.7	
Partially dependent	0.6	2.2	
Totally dependent	0.1	1.1	

SD = standard deviation.

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Table 2

Intraoperative characteristics and SSI.

Variable	Patients without SSI (*n* = 49,147)	Patients with SSI (*n* = 179)	*P* value
Operative time, min, mean ± SD	117.1 ± 62	157 ± 112.4	<0.001
Wound classification, %			<0.001
Clean (*n* = 48,299)	98	86.6	
Clean-contaminated (*n* = 833)	1.7	11.7	
Contaminated (*n* = 180)	0.4	1.7	
Dirty (*n* = 14)	0.03	0	

SD = standard deviation.

Table 3

Postoperative outcomes and SSI.

Variable	Patients without SSI (*n* = 49,147)	Patients with SSI (*n* = 179)	*P* value
Unplanned intubation (*n* = 183), %	0.4	1.7	0.004
Urinary tract infection (*n* = 164), %	0.33	1.12	0.07
Ventilator > 48 h (*n* = 127), %	0.3	2.2	<0.001
Pneumonia (*n* = 106), %	0.2	1.7	<0.001
Sepsis (*n* = 68), %	0.1	9.5	<0.001
Bleeding requiring transfusion (*n* = 49), %	0.09	3.4	<0.001
Wound disruption (*n* = 30), %	0.04	4.5	<0.001
DVT or thrombophlebitis (*n* = 28), %	0.06	0	0.75
Peripheral nerve injury (*n* = 27), %	0.05	0	0.8
Cardiac arrest requiring CPR (*n* = 27), %	0.05	0	0.8
Septic shock (*n* = 24), %	0.05	0	0.8
MI (*n* = 23), %	0.05	0	0.8
Pulmonary embolism (*n* = 22), %	0.04	0.6	0.001
Stroke, CVA with neurologic deficit (*n* = 18), %	0.04	0	0.8
Acute renal failure (*n* = 8), %	0.01	0.6	<0.001
Progressive renal insufficiency (*n* = 5), %	0.01	0.6	<0.001
Coma >24 h (*n* = 5), %	0.01	0	0.9
Return to OR (*n* = 1132), %	2.23	19	<0.001
Length of stay, mean ± SD	1.3 ± 5.1	3.2 ± 5.8	<0.001

CPR = cardiopulmonary resuscitation; CVA = cerebrovascular accident; DVT = deep venous thrombosis; SD = standard deviation.

Table 4

Multivariate logistic model with preoperative predictor variables at higher risk for SSI.

Variable	Odds ratio	95% Confidence interval	*P* value
Obesity (BMI > 30)	1.8	1.3, 2.5	0.001
Alcohol use	2.7	1.0, 7.4	0.049
Partially dependent	2.9	1.0, 8.2	0.049
Totally dependent	5.8	1.3, 26.5	0.024
Weight loss > 10%	2.8	1.0, 7.8	0.05
Steroids	2.1	1.0, 4.6	0.06
Central neck dissection	1.5	0.9, 2.5	0.14
Insulin-dependent diabetes	1.7	0.9, 3.3	0.09
Diabetes on oral agents	1.7	0.9, 3.0	0.08
COPD	1.7	0.8, 3.7	0.21

Variables also included in model that were clearly not associated with significant odds of predicting SSI were partial thyroidectomy, thyroidectomy with radical lymph node dissection, reoperative thyroidectomy, thyroidectomy with substernal goiter, underweight (BMI<19), diabetes not requiring medications, and history of CHF.

Table 5

Multivariate logistic model with intraoperative factors in addition to preoperative predictor variables at higher risk for SSI.

Variable	**Odds ratio**	**95% Confidence interval**	***P* value**
Clean-contaminated wound	6.1	3.6, 10.3	<0.001
Operative time (for each extra min)	1.004	1.002, 1.006	<0.001
Obesity (BMI > 30)	1.8	1.3, 2.5	0.001

Variables also included in model that were not associated with significant OR predicting SSI were partial thyroidectomy, thyroidectomy with central lymph node dissection, thyroidectomy with radical lymph node dissection, reoperative thyroidectomy, thyroidectomy with substernal goiter, underweight (BMI <19), diabetes (insulin-controlled, diet-controlled, or oral agents), alcohol use, steroid use, history of CHF, history of COPD, weight loss > 10%, and partially or totally dependent functional status.

Table 6

Multivariate logistic regression model for association of SSI with other postoperative complications.

Variable	Odds ratio	95% Confidence interval	*P* value
Return to operating room	5.5	3.5, 8.9	<0.001
Wound dehiscence	24.1	8.1, 71.3	<0.001
Acute renal failure	35.7	3.4, 376.3	0.003
Renal insufficiency	70.4	6.6, 747.9	<0.001
Sepsis	75.3	35.1, 161.5	<0.001

Variables also included in model that were not associated with significant OR associated with SSI were: pneumonia, reintubation, failure to wean from ventilator, pulmonary embolus, urinary tract infection, bleeding requiring transfusion, and length of stay.